Prepared by Julian García, based on material by
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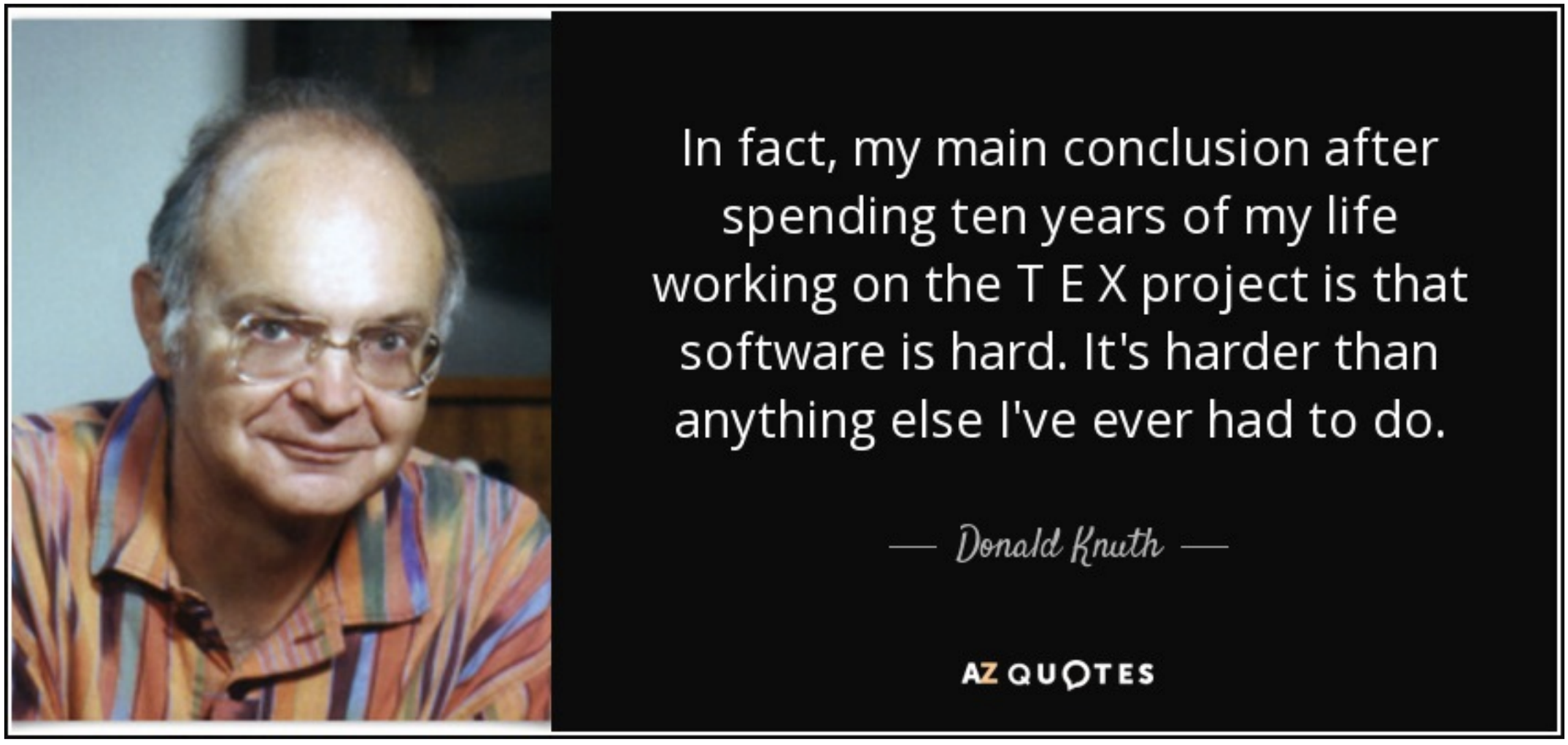
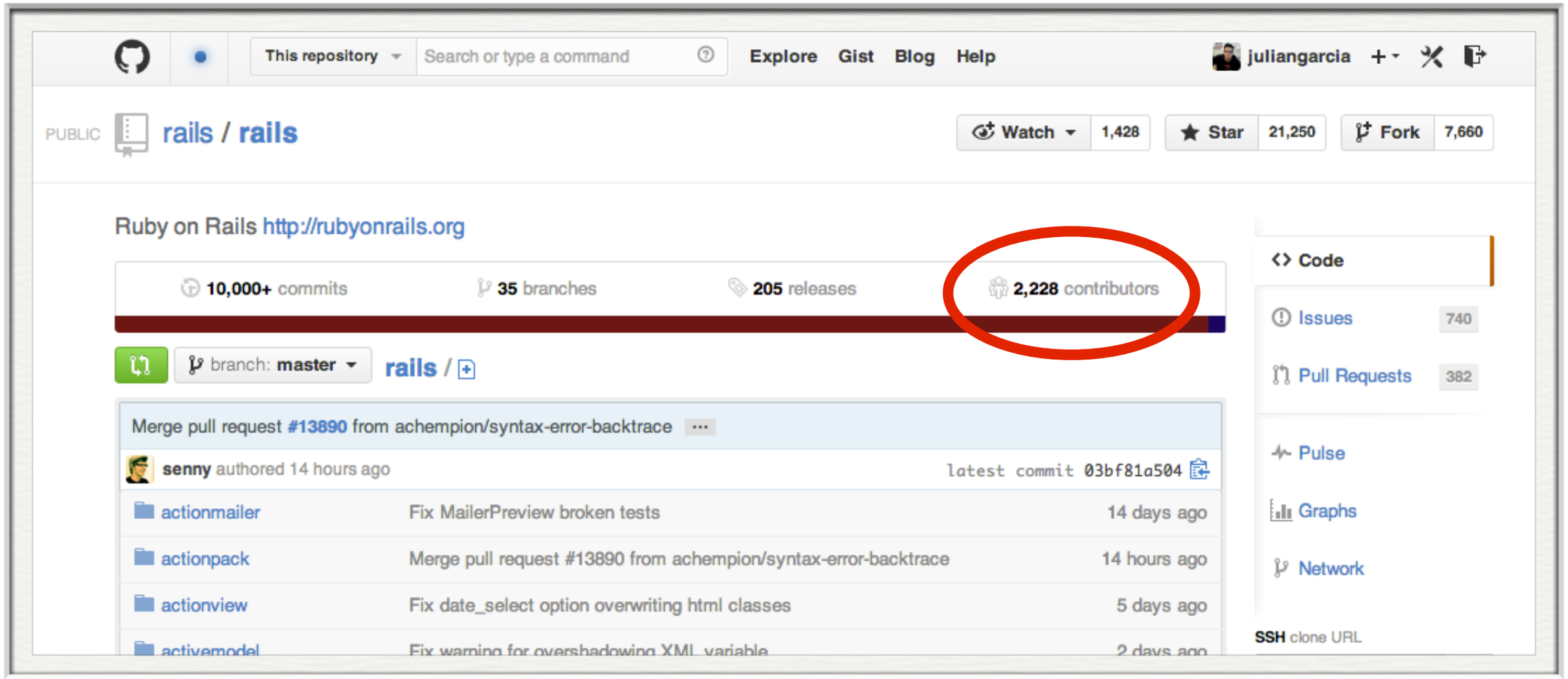
Lecture 13
ADT, Classes and Objects

FIT 1008
Introduction to Computer Science


In fact, my main conclusion after spending ten years of my life working on the T E X project is that software is hard. It's harder than anything else I've ever had to do.
— Donald Knuth —
AZ QUOTES



2228 contributors

Abstraction

Concepts & Ideas

Algorithms

Data Structures

Organise information

Known examples:
Graphs, Tables,
Bitstrings, Lists, Etc.

Manipulation requires we know specifics.

Abstract Data Types

Data structures
along with their operations

Manipulation through operations.

Designed based on: **Abstraction Encapsulation, Information Hiding.**

Computer Programs

Data Types

Tangible things.

Data Structures

Organise information

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Graphs, Tables,
Bitstrings, Lists, Etc.
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Manipulation through **operations**.

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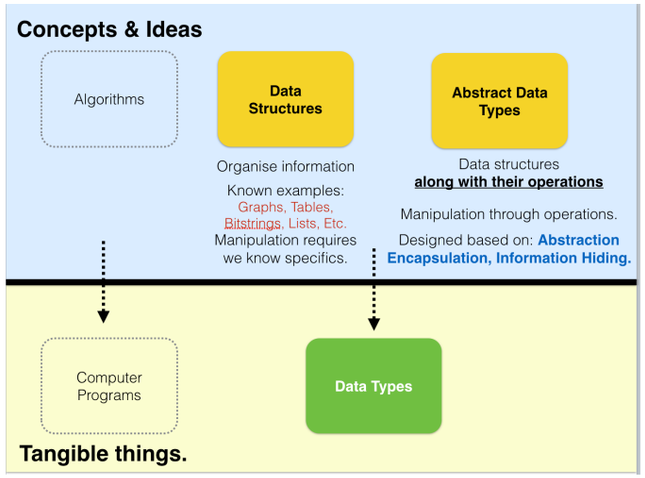


Data Types

- Refers to a classification that determines:
  - The possible **values** for that type
  - The **meaning** of those values
  - The **operations** that can be done on them
  - The way those values are **implemented**

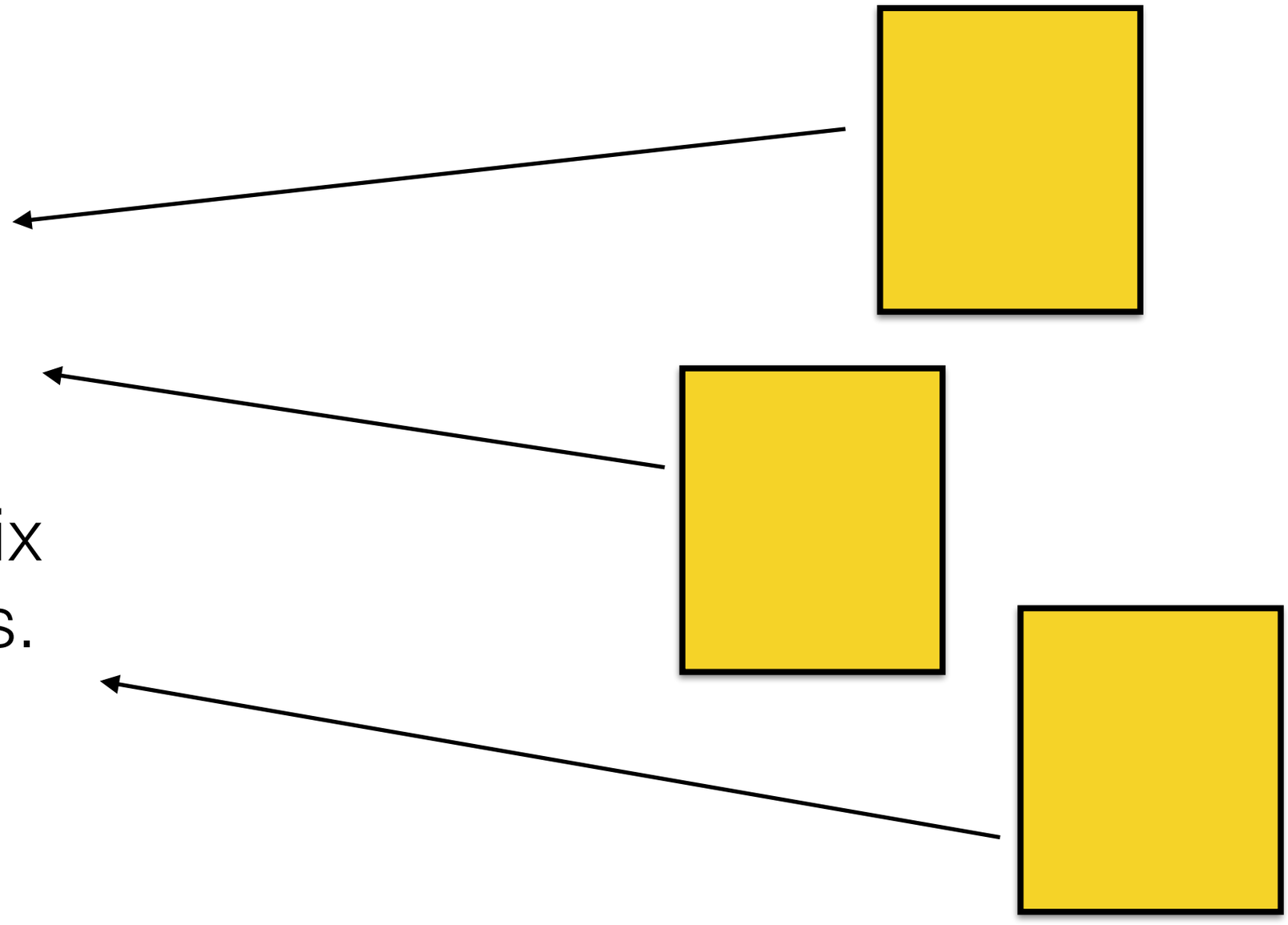
- **Example**: In Java if variable has type ***int***
  - It can take values from -2,147,483,648 to 2,147,483,647
  - Its **meaning** is that of an integer number
  - Can be used in all integer operations (add, subtract, etc)
  - Implemented using 32 bits and specific bytecode operations

used in different parts of a program

Graph

	V_1	V_2	V_3	V_4
V_1	0	1	0	1
V_2	1	0	1	1
V_3	0	1	0	0
V_4	1	1	0	0

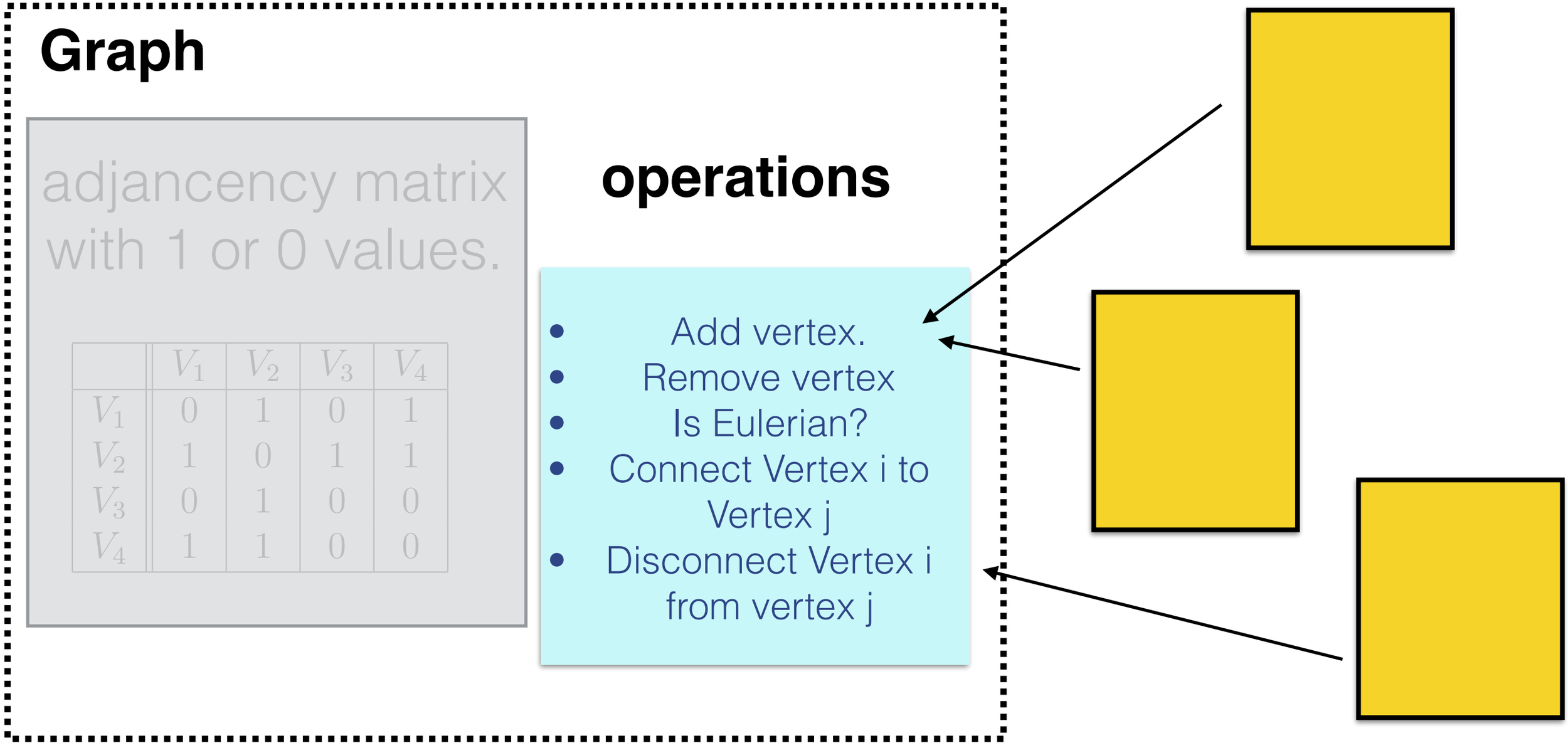
adjancency matrix with 1 or 0 values.



usage requires that I know **how** my graphs are implemented

as an **Abstract Data Type**

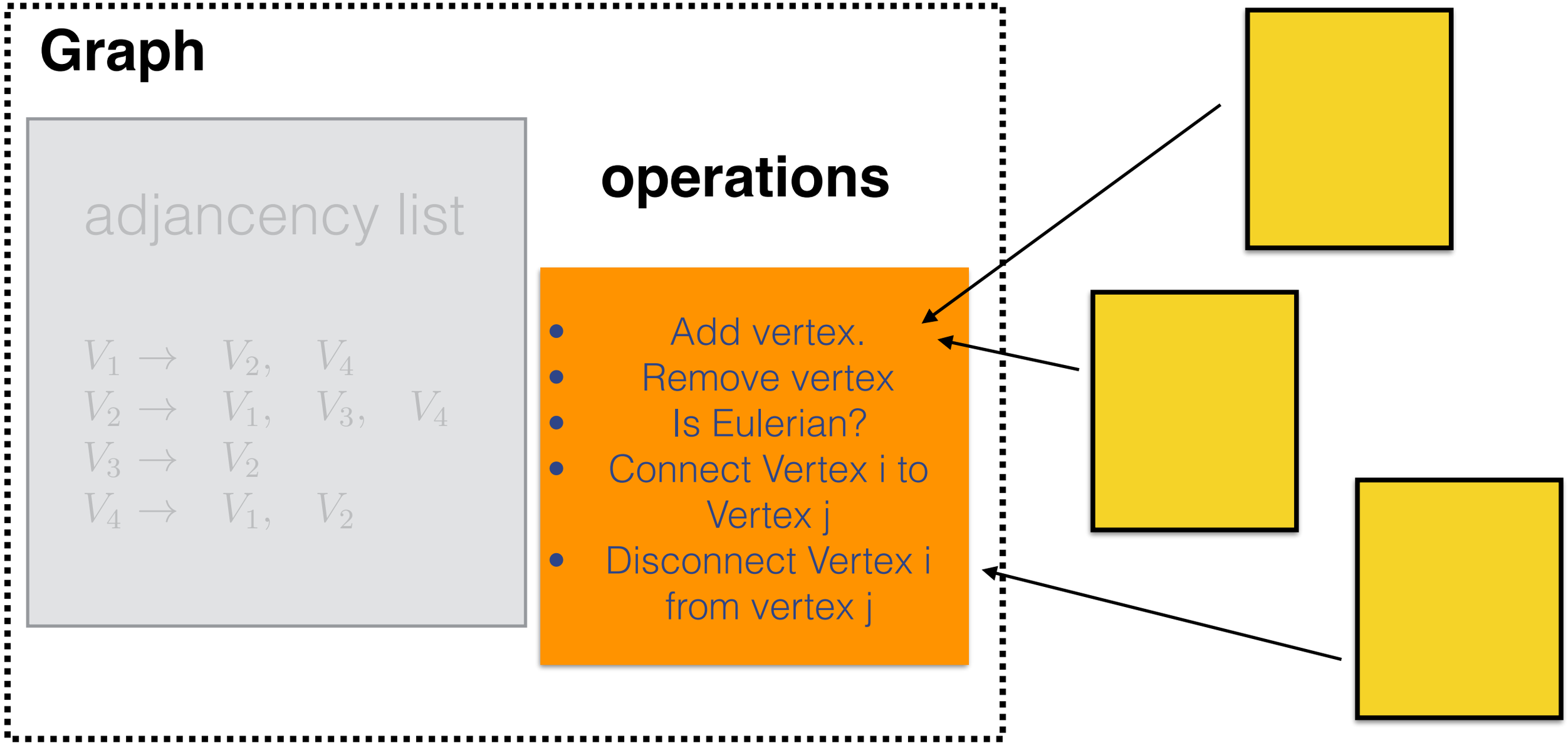
used in different parts of a program



usage through **operations (a.k.a interface)**!

as an **Abstract Data Type**

used in different parts of a program



usage through **operations (a.k.a interface)**!

No changes outside!

Abstract Data Types (ADTs)

- Often **no need to know** how types are **implemented**
- An abstract data type:
  - Provides information regarding:
    - The possible **values of the type** and their meaning
    - The **operations** that can done on them
  - BUT not on its implementation, i.e. how:
    - The values are stored
    - The operations are implemented
  - **Users interact with the data only through the provided operations**

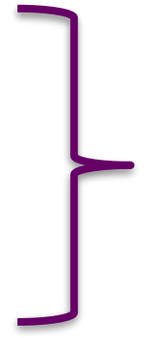
Data Structures

- At some point we must give ADTs an implementation. Information needs to be organised.

- Some ADTs contain several data fields
  - How do we organise the data? How do we access it?

- That is what a **data structure** provides:
  - A particular way in which data is physically organised (so that certain operation can be performed efficiently)

- Example: the **array** data structure
  - Fixed size
  - Data items are stored sequentially
  - Each item occupies the same amount of space



Rational ADT

- **Representation** of rationals
  (two integers, p and q, q not zero).

DATA STRUCTURE

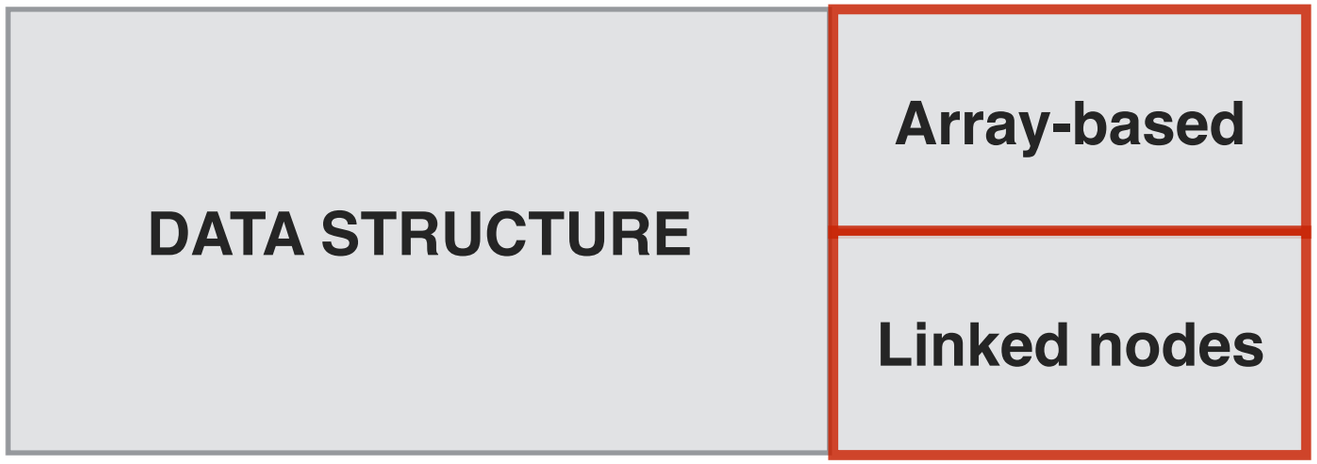
- Possible **Operations**:
  - Arithmetic operations, +, -, /, *
  - Comparison operations, <, >, ==, <=, >=
  - Equality =
  - Read
  - Print

OPERATIONS

Container ADTs

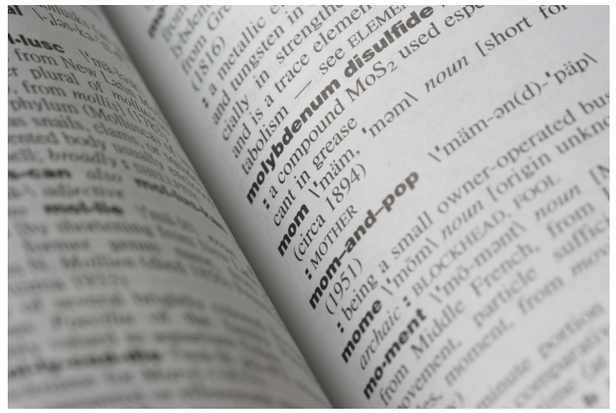
- **Stores** and removes items **independent of contents.**

- **Examples** include:
  - List ADT
  - Stack ADT
  - Queue ADT.



- Core **operations**:
  - ➡ add item
  - ➡ remove item

Dictionary ADT



- Permits **access to data items by content**, e.g., a key.
- Operations
  - Search
  - Insert
  - Delete

OPERATIONS

DATA STRUCTURE	Hash-table
	Binary Search Tree

Example: A dictionary of student names, whose key is the student ID.

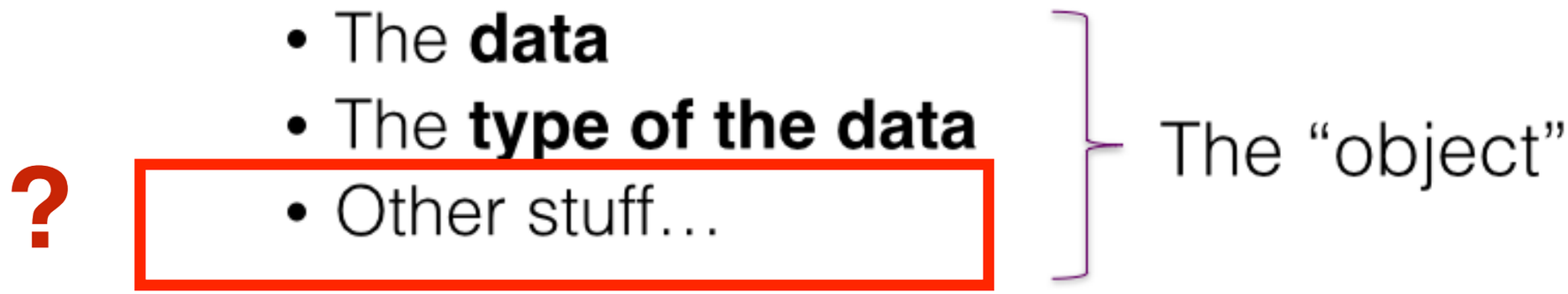
How to implement ADT?

- Learn some **Object Oriented Programming** (in Python)
- In particular, to learn:
  - How to **define basic <u>classes</u>**
  - How to **instantiate them into <u>objects</u>**
  - How to define **<u>methods</u>** and how to use them
  - An example of classes for implement stacks
  - The importance of **namespaces and scoping rules**

- We will **NOT** learn about a major OO component: **inheritance**
  - Not needed for FIT1008
  - Central to the idea of OO

Objects

- **Objects**: blocks of memory containing some data.



- Objects are more than **data** fields (or data attributes).
  They **also** have **methods** that can be performed by the object.

- Like real life: **Objects** interact with each other (through methods.)

Using Objects

- Every value is an object with **data and methods.**

- So, how do we access the data and methods of an object? Through the **“dot”** notation:

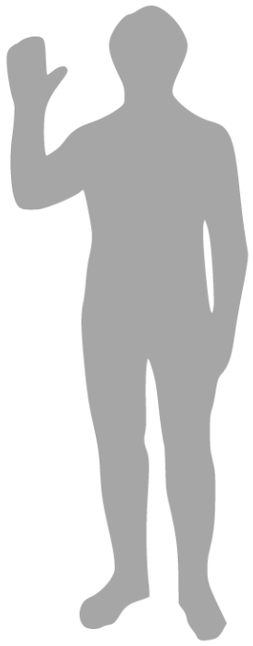
```
>>> "abcd".upper()
'ABCD'
```

```
>>> x = [1,2,3,4]
>>> x.append(5)
>>> x
[1, 2, 3, 4, 5]
```

- Also referred to as “**qualifying**” a variable or method.

- The **dot notation is common** to many languages (e.g. Java.)

Class:



blueprint

Objects:

instances…

Classes

- A class is a **blueprint** for objects, defines **attributes**: data + methods

- Classes are defined using the following syntax:

Convention: Class name starts with uppercase

class is a keyword

class header

```
class ClassName:
    <statement-1>
    .....
    <statement-N>
```

body is indented

class body

Statement-i are mostly “methods”

- Every object is created by **instantiating** a class (see later).

- That is why we say that an **object is an instance of a class.**

Methods

- Define **operations** that can be performed by any object created as an instance of the class
- A method definition looks like a function definition

- Except that:
  - It must appear inside the class (in the body)
  - Its first argument must be a reference to the instance whose method was called
    - By **(a very strong) convention**, this argument is named **`self`**
    - You must **explicitly** add **`self`** to the method **definition**
    - But it is **automatically** added in a **method call**

The __init__ method

double underscore

double underscore

- By **convention** it is the first method in a class.
- First code **executed when creating an instance** (automatically!)
- You can choose not to define it.
- Its first argument (**self**) is a reference to the **instance** whose method was called.

Point Class

don't forget **self**

Local variables

```
class Point:
    def __init__(self, x, y):
        self.x_coordinate = x
        self.y_coordinate = y
```

Instance variables

- **Instance variables** start with **self**:
  - Their **value** is specific to each instance.
  - Their **name** is global to all methods in the class. You can access it from every method in the class.

- If a variable does not start with self it is **local** to the method that binds it. Local variables can't be seen by other methods.

Let's put this into a file called *point.py*

```
class Point:
    def __init__(self, x, y):
        self.x_coordinate = x
        self.y_coordinate = y
```

```
>>> import point
>>> p1 = point.Point(1,3)
>>> p1.x_coordinate
1
>>> p1.y_coordinate
3
>>> p2 = point.Point(-4,7)
>>> p2.x_coordinate
-4
>>> p2.y_coordinate
7
>>> p1.__class__
<class 'point.Point'>
```

Recap

- ADT = data + functionality (together)
- Functions **hide** implementation.
- We implement ADT using classes.

- We create a **class** by:
  - Simply writing class Name, in some file.
  - Adding **indented statements** (such as methods) to it
  - All methods have **self** as first argument

- We create an **object**:
  - By instantiating the class. Calling Name() with the appropriate arguments, as given by **__init__**
  - The object has access to all the **attributes** defined by the class using the **"dot" notation** (e.g., the_stack.push)